ARMY RESEARCH LABORATORY

Development of a Ballistic Specification for Magnesium Alloy AZ31B

by Tyrone L. Jones and Richard D. DeLorme

ARL-TR-4664 **December 2008**

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Army Research Laboratory
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14. ABSTRACT
The U.S. Army Research Laboratory (ARL) and Magnesium Elektron North America (MENA) have conducted a joint effort to develop and evaluate rolled plate in commercially available magnesium alloy-temper AZ31B-H24. MENA produced the rolled product and conducted the mechanical analysis, while ARL performed the ballistic analysis. The magnesium alloy plates were parametrically compared with the minimum performance requirements of aluminum alloy 5083-H131 temper rolled plate using various armor-piercing and fragment-simulating projectiles (FSPs). The ballistic results and comparisons are presented herein. The yield strength of AZ31B-H24 is the dominant mechanical property that will improve the performance at increased weights.

15. SUBJECT TERMS
magnesium, aluminum, AZ31B, 5083, ballistic performance, military specification, protection

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Acknowledgments

The development of these aluminum alloy armor solutions were performed with assistance from the following technicians: Donnie Little, Vaughn Torbert, and Shawn Thomas for the testing of these plates against armor-piercing projectiles and fragment-simulating projectiles.

1. Background

The U.S. Army is interested in providing greater ballistic protection at lower weight; thus, magnesium-based alloys are currently of interest because the density of magnesium (~1.77 g/cm^3) is ~35% lower than aluminum (~2.68 g/cm^3) and ~77% lower than steel (*1*).

In general, there is a positive correlation between tensile strength and small arms ballistic performance in metal alloys. Although the tensile strength of rolled magnesium alloys is traditionally lower than that of rolled aluminum armor alloys, magnesium may possess other unique characteristics, including superior vibration damping and differences in failure mechanisms, that could provide for improved relative ballistic performance (*2*).

The data generated in this manuscript will be used to develop the ballistic specification for magnesium alloy AZ31B.

2. Chemical Composition

The chemical composition limits of magnesium alloy AZ31B are listed in table 1, as specified by the commercial material specification AMS-4377H (*3*). The chemical composition limits of aluminum alloy 5083 are listed in table 2 per military material specification MIL-DTL-46027K (MR) (*4*).

Table 1. Magnesium alloy AZ31B chemical composition limits (weight-percent).

	Al	**Zn**	**Mn**	**Si**	**Cu**	**Ca**	**Fe**	**Ni**	**Others Each**	**Others Total**	**Mg**
Max.	3.5	1.3	—	0.05	0.05	0.04	0.005	0.005	0.10	0.30	Balance
Min.	2.5	0.7	0.20	—	—	—	—	—	—	—	

Table 2. Aluminum alloy 5083 chemical composition limits (weight-percent).

	Si	**Fe**	**Cu**	**Mn**	**Mg**	**Cr**	**Zn**	**Ti**	**Others Each**	**Others Total**	**Al**
Max.	0.40	0.40	0.10	1.2	4.9	0.25	0.25	0.15	0.05	0.15	Balance
Min.	—	—	—	0.40	4.0	0.05	—	—	—	—	

3. Mechanical Properties

Magnesium Elektron North America provided typical tensile properties of rolled AZ31B-H24 magnesium plate and rolled 5083-H131 aluminum alloy plate. These mechanical properties were accumulated in a database of rolled plate produced at its Madison, IL, facility over a 7-year period. All plates were manufactured in accordance with ASTM-B90 (*5*) and/or AMS-4377 (AZ31B-H24) and MIL-A/DTL-46027K (5083-H131) (*6*). This historical data is presented in tabular format in tables 3 and 4 and in graphical format in figures 1–3.

Table 3. Typical Mg AZ31B-H24 plate tensile properties.

Thickness Range	Ultimate Tensile Strength (ksi)	Tensile Yield Strength (ksi)	Elongation (%)
0.376–0.500	39.2	25.6	14.4
0.501–0.750	38.6	24.4	13.5
0.751–1.000	38.4	24.0	13.1
1.001–1.500	38.2	24.3	12.5
1.501–2.500	38.3	24.6	11.9
2.501–3.500	37.9	24.0	11.1

Table 4. Typical Al 5083-H131 plate tensile properties.

Thickness Range	Ultimate Tensile Strength (ksi)	Tensile Yield Strength (ksi)	Elongation (%)
0.376–0.500	50.4	42.5	13.4
0.501–0.750	51.2	42.6	12.7
0.751–1.000	51.5	45.0	10.1
1.001–1.500	50.9	43.9	10.1
1.501–2.500	50.2	42.5	10.9
2.501–3.500	48.1	39.1	13.8

While the AZ31B-H24 and 5083-H131 exhibit similar ductility (% elongation), the 5083-H131 is superior in ultimate tensile strength (UTS) by 10–12 ksi (69–83 MPa) and in tensile yield strength (TYS) by 15–19 ksi (103–131 MPa). However, as shown in tables 5 and 6 and in figures 4 and 5, the specific strength of AZ31B-H24 is superior to 5083-H131 in specific UTS and approaching 5083-H131 in specific TYS. Then, based on the positive general correlation between tensile properties and ballistic performance, one might predict a similar relationship in terminal ballistic performance between rolled AZ31B-H24 plate and rolled 5083-H131 plate. Clearly, the relatively lower specific TYS may reduce fragment-simulating projectile (FSP) performance.

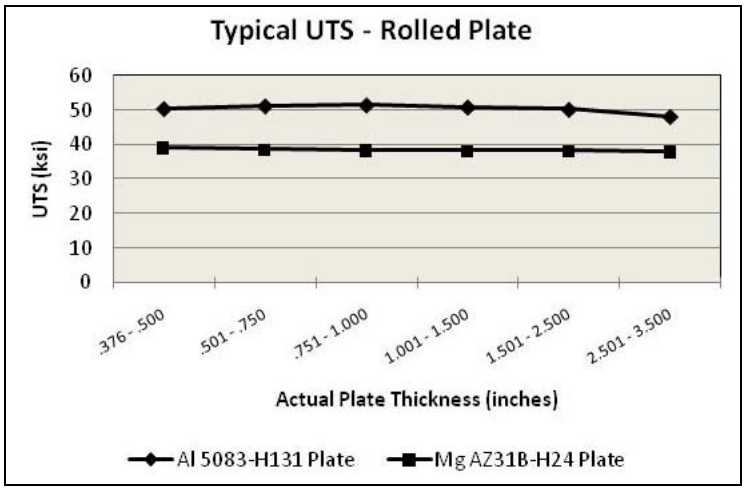

Figure 1. UTS – AZ31B-H24 vs. 5083-H131.

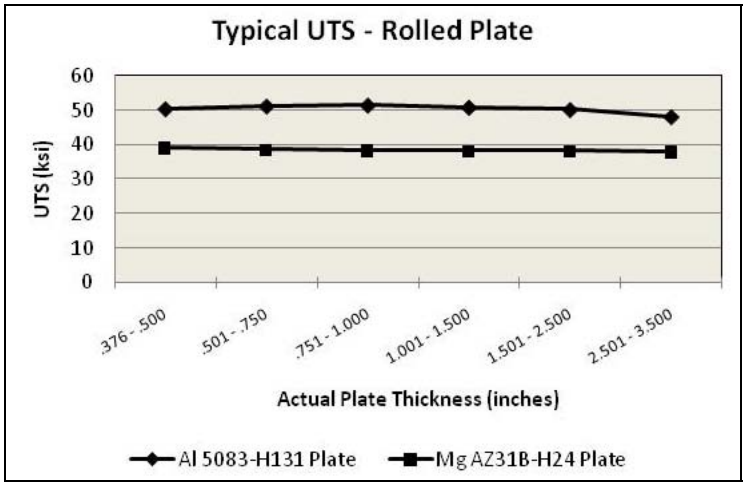

Figure 2. TYS – AZ31B-H24 vs. 5083-H131.

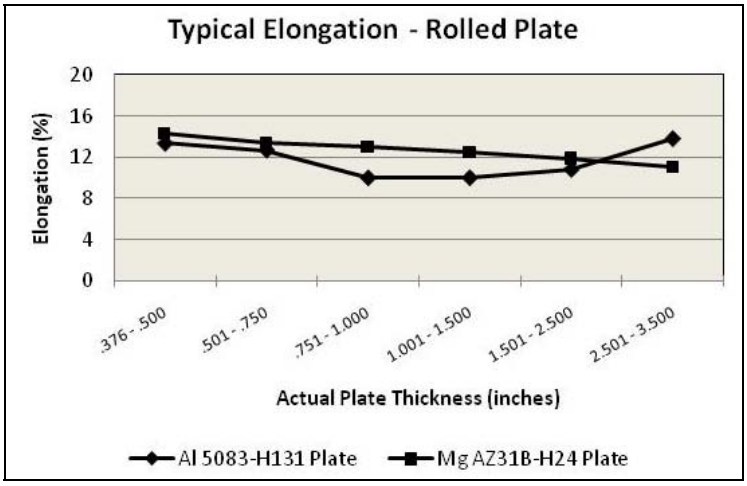

Figure 3. Percent elongation – AZ31B-H24 vs. 5083-H131.

Table 5. Typical Mg AZ31B-H24 plate specific strength.

Thickness Range	Specific Ultimate Tensile Strength (ksi-cu in/lb)	Specific Tensile Yield Strength (ksi-cu in/lb)
0.376–0.500	613	399
0.501–0.750	602	380
0.751–1.000	600	375
1.001–1.500	597	380
1.501–2.500	598	384
2.501–3.500	592	375

Table 6. Typical Al 5083-H131 plate specific strength.

Thickness Range	Specific Ultimate Tensile Strength (ksi-cu in/lb)	Specific Tensile Yield Strength (ksi-cu in/lb)
0.376–0.500	520	438
0.501–0.750	528	439
0.751–1.000	530	463
1.001–1.500	524	452
1.501–2.500	517	438
2.501–3.500	495	403

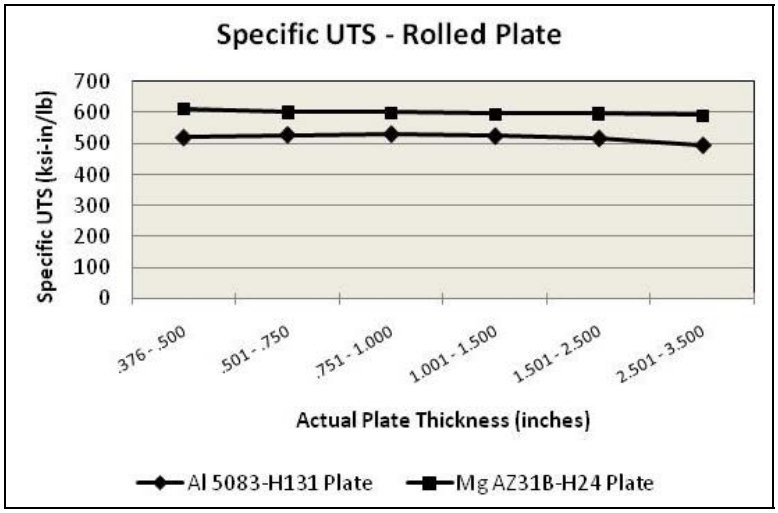

Figure 4. Specific UTS – AZ31B-H24 vs. 5083-H131.

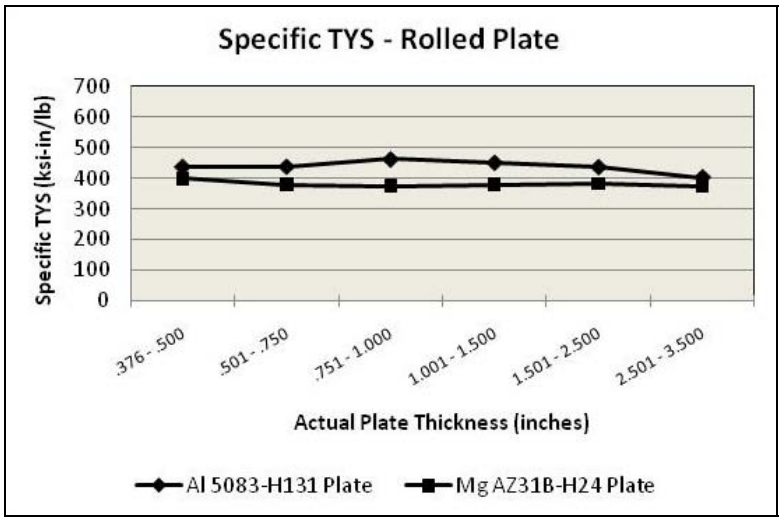

Figure 5. Specific TYS – AZ31B-H24 vs. 5083-H131.

4. Terminal Ballistic Evaluation

Ballistic testing of all rolled AZ31B-H24 magnesium plate samples was performed by the U.S. Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD, in accordance with MIL-STD-662F (*7*). Ballistic results were characterized using the standard V_{50} test methodology, also documented in MIL-STD-662F. The ballistic projectiles were selected for each nominal plate thickness as specified by the 5083-H131 armor material specification MIL-DTL-46027K (MR). The specific projectiles used to evaluate the magnesium alloy plates were the 0.30-cal. APM2 and the 0.50-cal. APM2, depicted in figure 6, and 0.50-cal. and 20-mm FSP, depicted in figure 7. The APM2 projectiles used were standard production, while the FSPs used were produced in accordance with MIL-DTL-46593B (MR) (*8*).

5. Experimental Results

The rolled plate of AZ31B-H24 and 5083-H131 was evaluated on an equivalent weight (i.e., areal density) basis. The AZ31B-H24 ballistic results vs. areal density are displayed in figures 8–11, and the same results vs. plate thickness are displayed in figures 12–15. See appendices A–C for AZ31B-H24 plate post-ballistic pictures and data at various thicknesses. The 5083-H131 data points in these figures are the minimum ballistic limit requirements per military material specification MIL-DTL-46027K (MR).

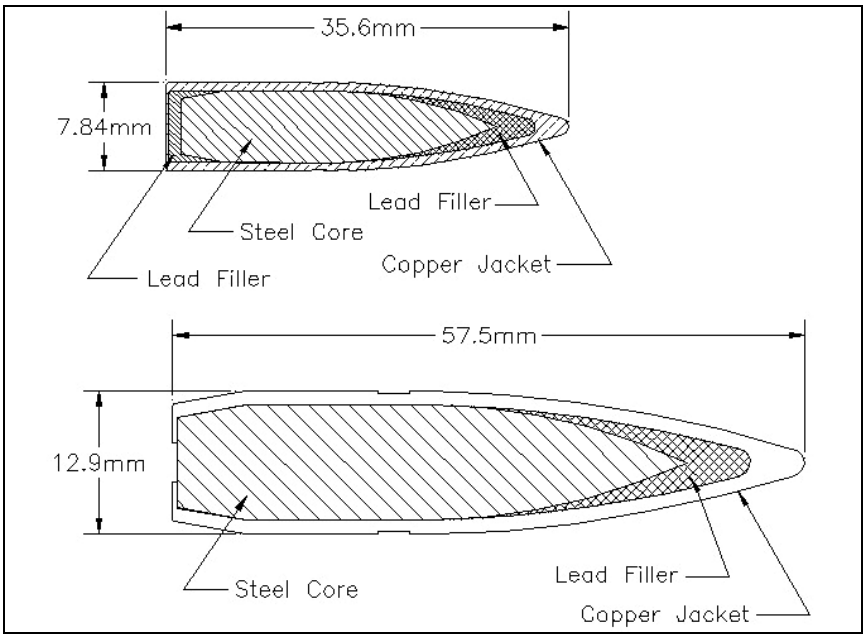

Figure 6. Diagrams of 0.30-cal. APM2 projectile (upper) and 0.50-cal. APM2 projectile (lower).

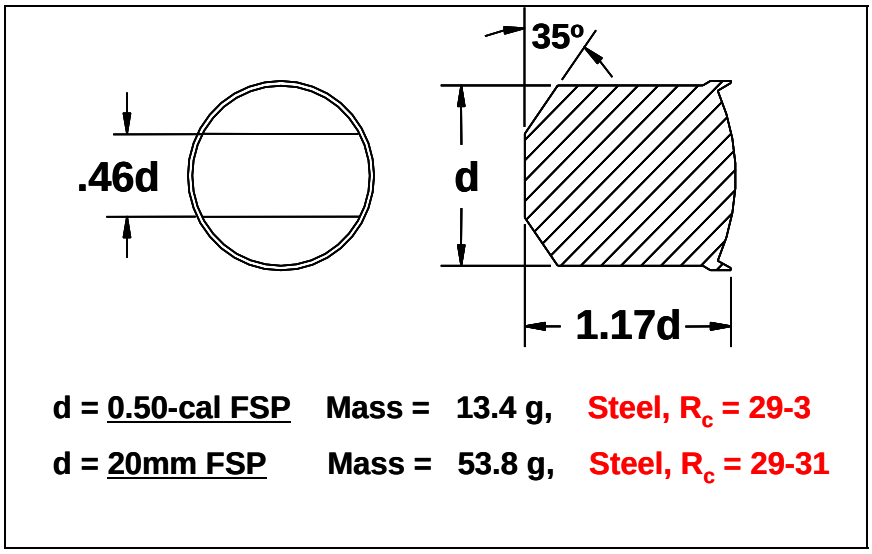

Figure 7. Diagram of 0.50-cal. FSP and 20-mm FSP.

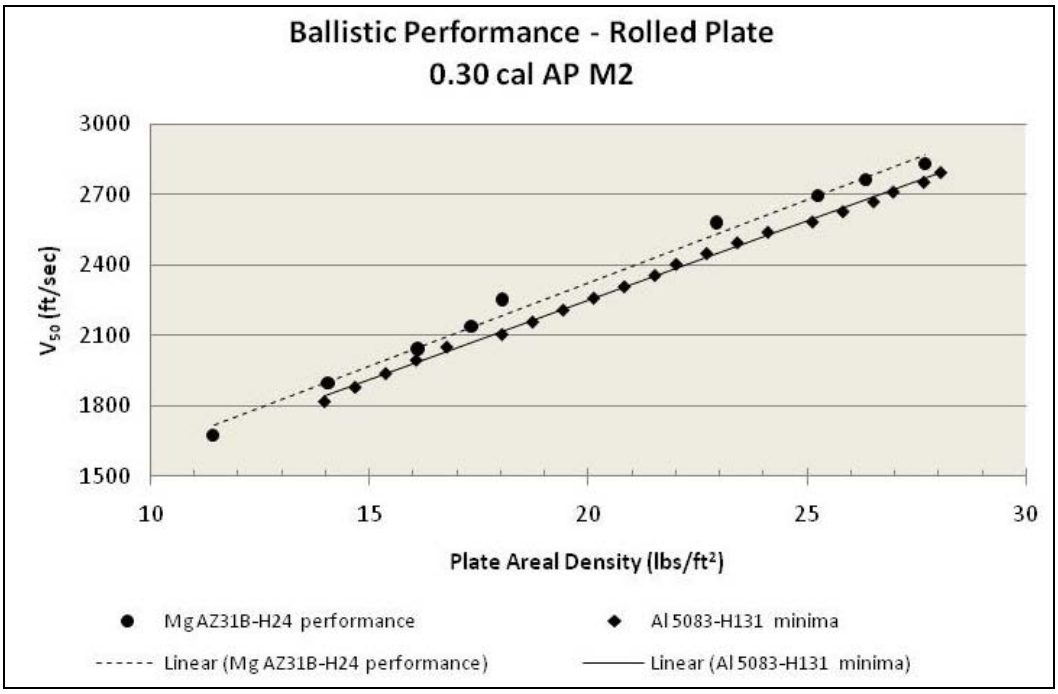

Figure 8. A 0.30-cal. APM2 performance comparison by areal density.

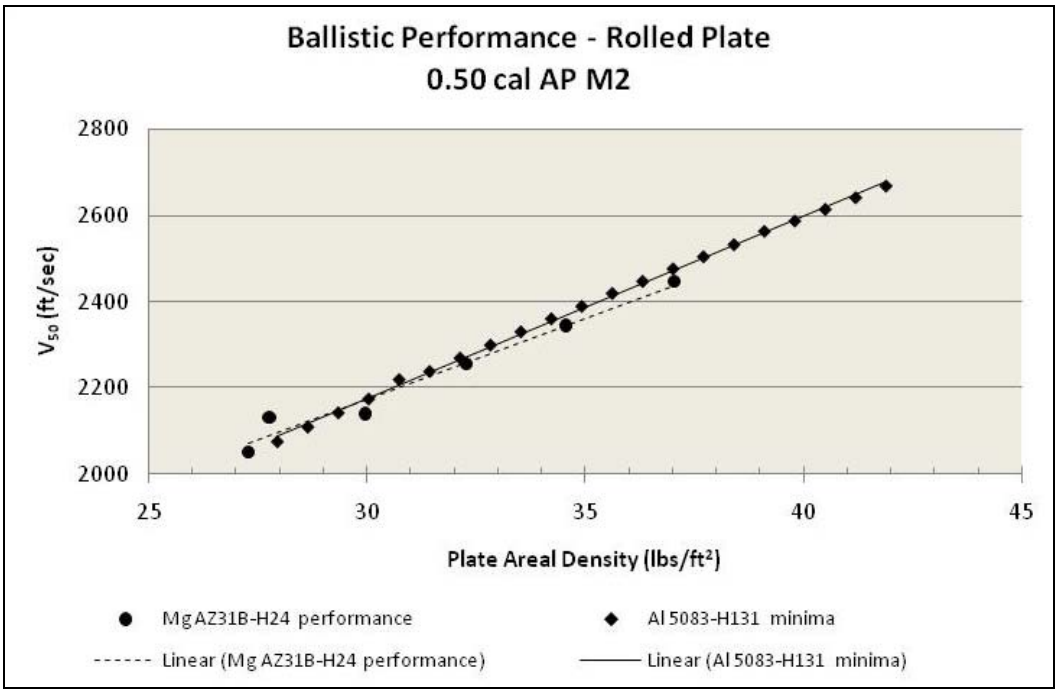

Figure 9. A 0.50-cal. APM2 performance comparison by areal density.

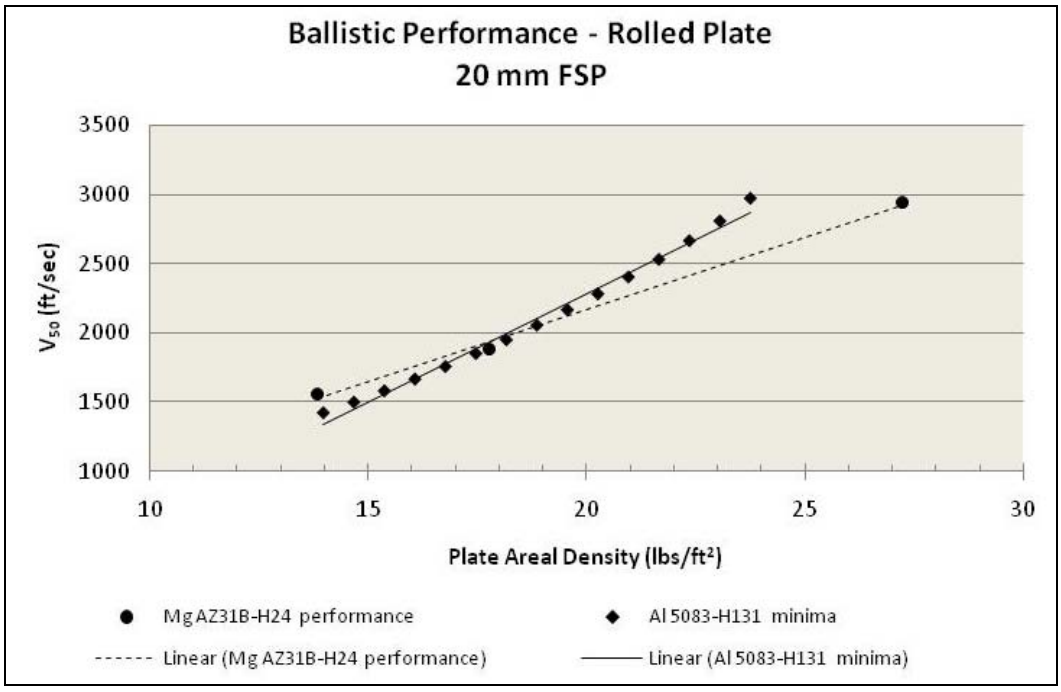

Figure 10. A 0.50-cal. FSP performance comparison by areal density.

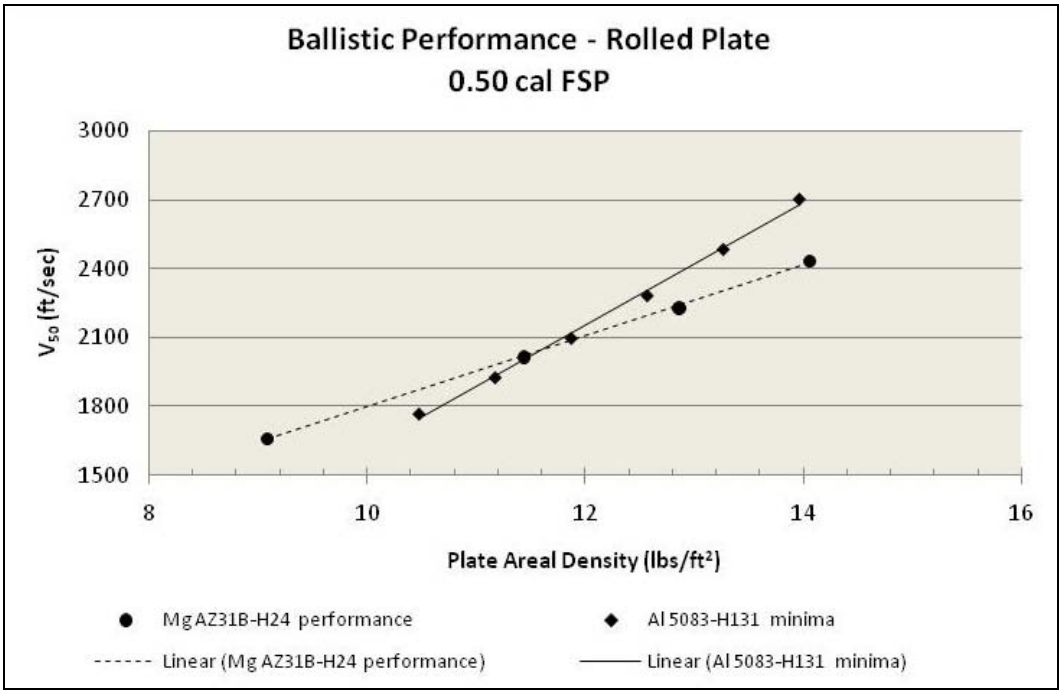

Figure 11. A 20-mm FSP performance comparison by areal density.

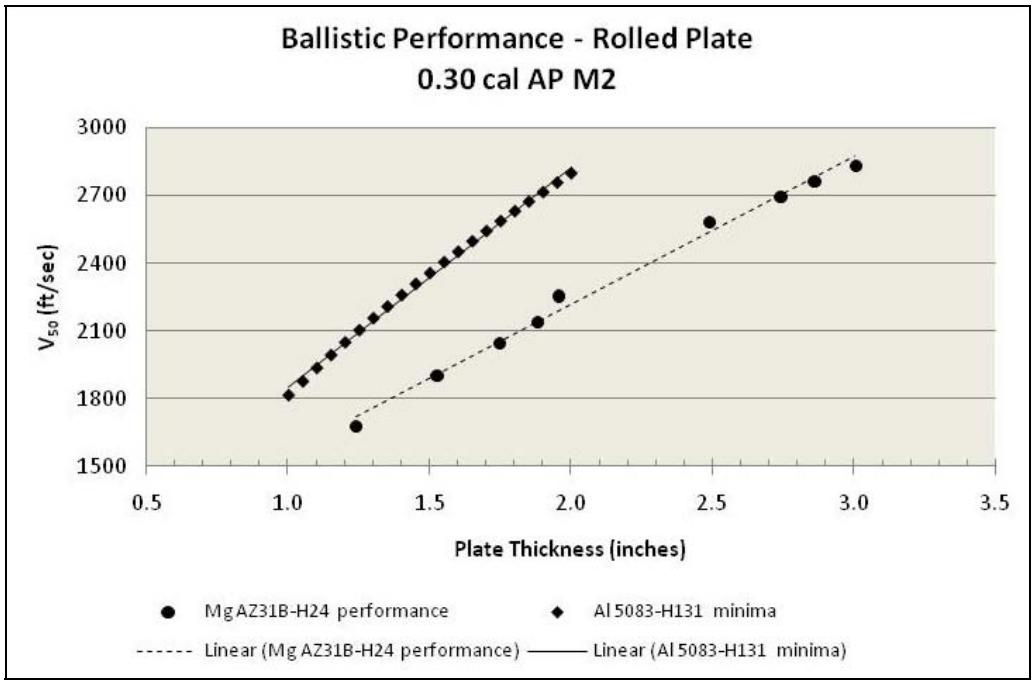

Figure 12. A 0.30-cal. APM2 performance comparison by plate thickness.

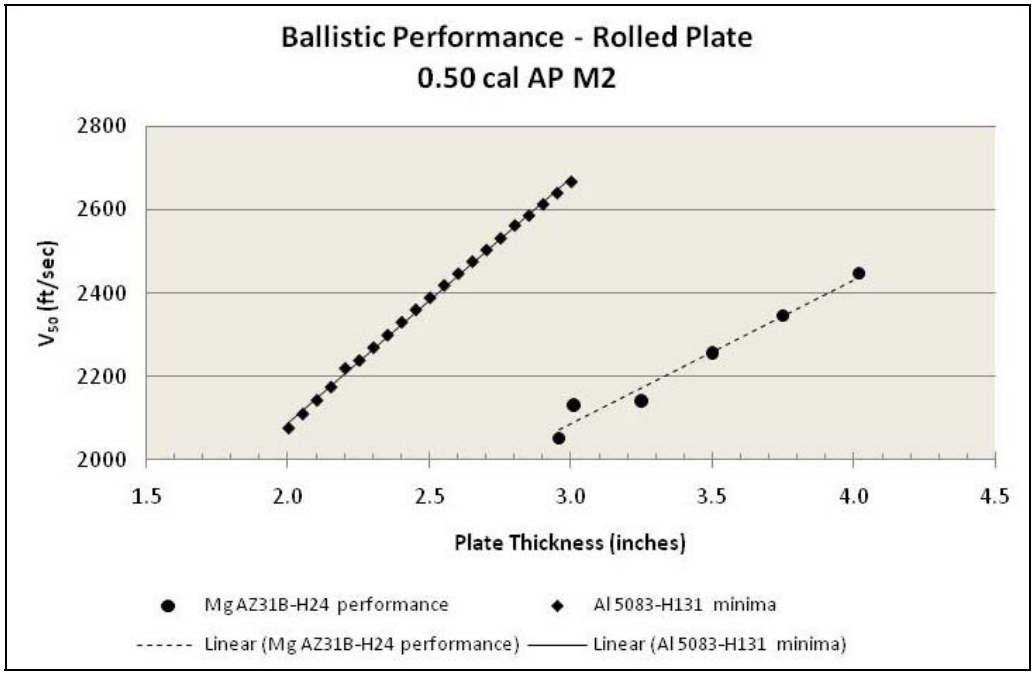

Figure 13. A 0.50-cal. APM2 performance comparison by plate thickness.

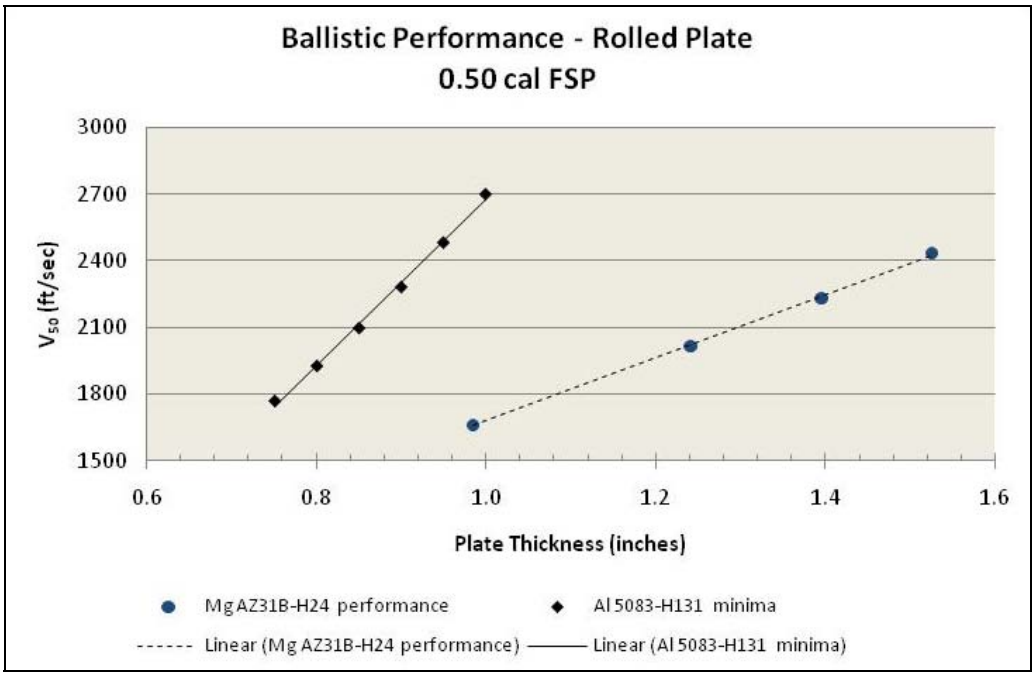

Figure 14. A 0.50-cal. FSP performance comparison by plate thickness.

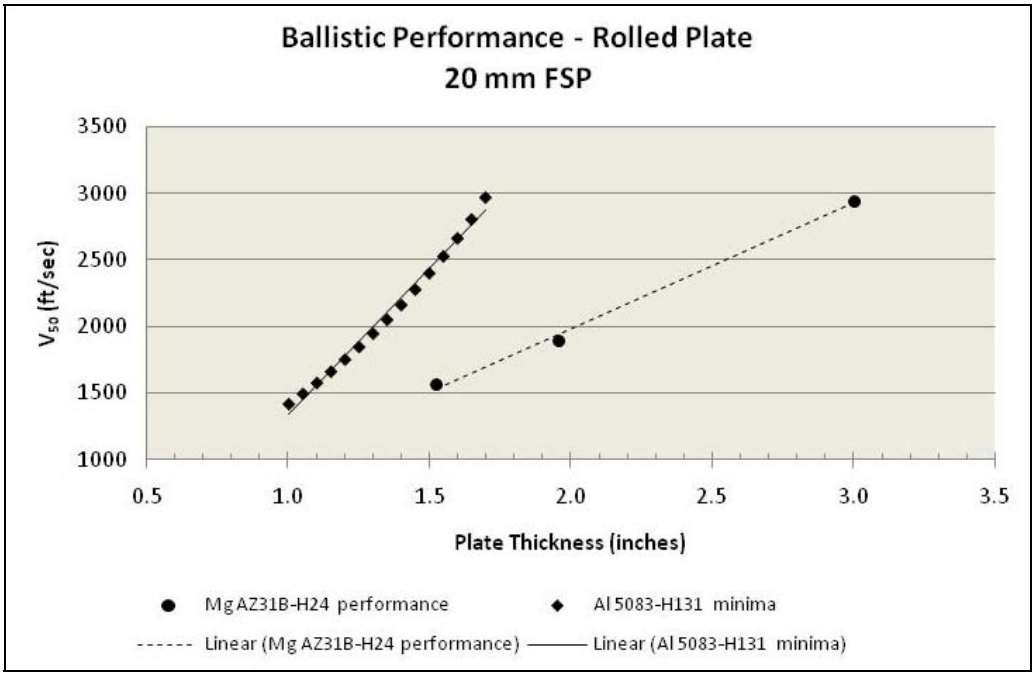

Figure 15. A 20-mm FSP performance comparison by plate thickness.

6. Discussion and Conclusion

On an equivalent weight basis, AZ31B-H24 plate performed just above (against the 0.30 cal.) or just below (against the 0.50 cal.) the 5083-H131 APM2 minimum ballistic performance limits, while its performance against the specified FSP was thickness-dependent (i.e., the lower thickness plate passed handily while the thicker plate fell short of the minimum requirements). These results indicate that rolled AZ31B-H24 magnesium plate may be an effective substitution for 5083-H131 against armor-piercing projectiles on an equivalent weight basis. Of course, weight-neutral AZ31B-H24 plate would be 50% thicker than the 5083-H131 it might replace, which would require consideration during the design of any armor system.

On a plate-thickness basis, the V_{50} AZ31B-H24 fell ~300 fps lower than the 5083-H131 minima against the armor-piercing projectiles and fell ~1000 fps short against the FSPs. This would indicate that the relatively lower TYS of AZ31B-H24 plate as compared to 5083-H131 plate might play a role in predicting the difference in terminal ballistic resistance between the materials compared. Therefore, further development of higher strength wrought magnesium alloys might reduce or close the performance gap between magnesium alloy and aluminum alloy plates.

An AZ31B-H24 armor material specification guide is expected to be completed in the near future. This guide will serve as a baseline for any future developments of magnesium alloys for armor.

7. References

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2. Jones, T. L.; DeLorme, R. D.; Burkins, M. S.; Gooch, W. A. Ballistic Performance of the Magnesium Alloy AZ31B. *Proceedings of the 23rd International Symposium on Ballistics*, Tarragona, Spain, 16–20 April 2007.

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6. Magnesium Elektron North America, Inc. Tensile Properties Lot Acceptance Database for 5083-H131 plate and AZ31B-H24 plate, 1999–2006.

7. MIL-STD-662F. *V50 Ballistic Test for Armor* **1997**.

8. MIL-DTL-46593B (MR). *Projectile, Calibers 0.22, 0.30, 0.50, and 20 MM Fragment-Simulating* **2006**.

Appendix A. Post-Ballistic Pictures

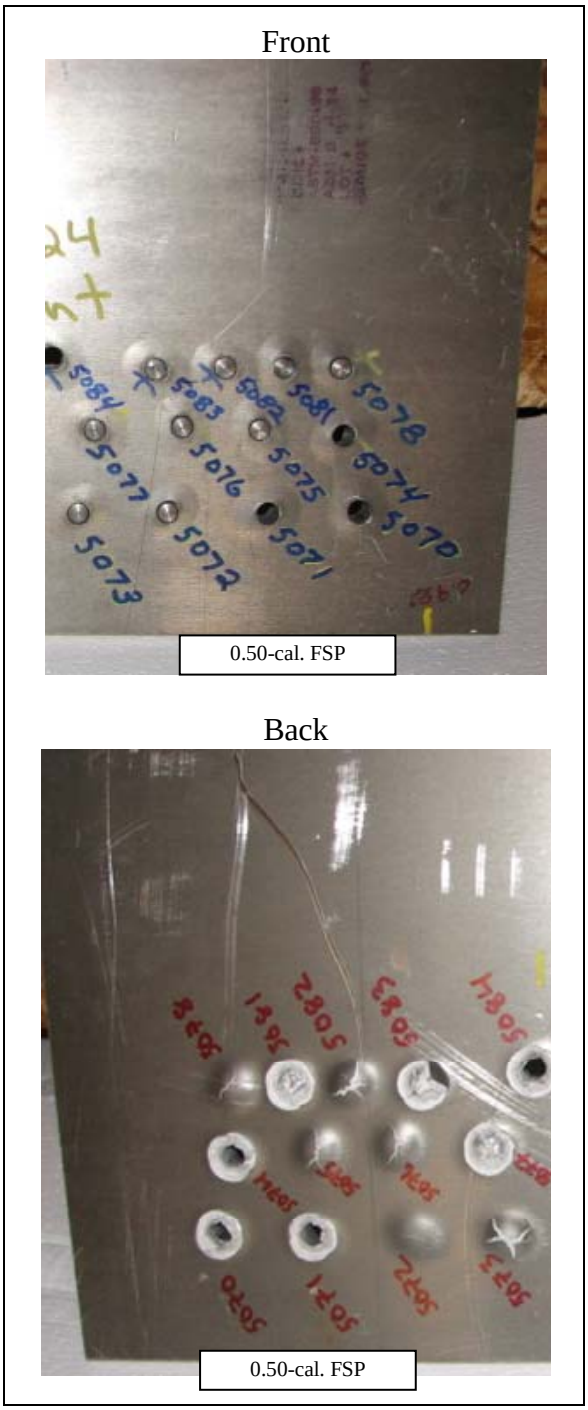


Figure A-1. The 1-in AZ31B-H24.

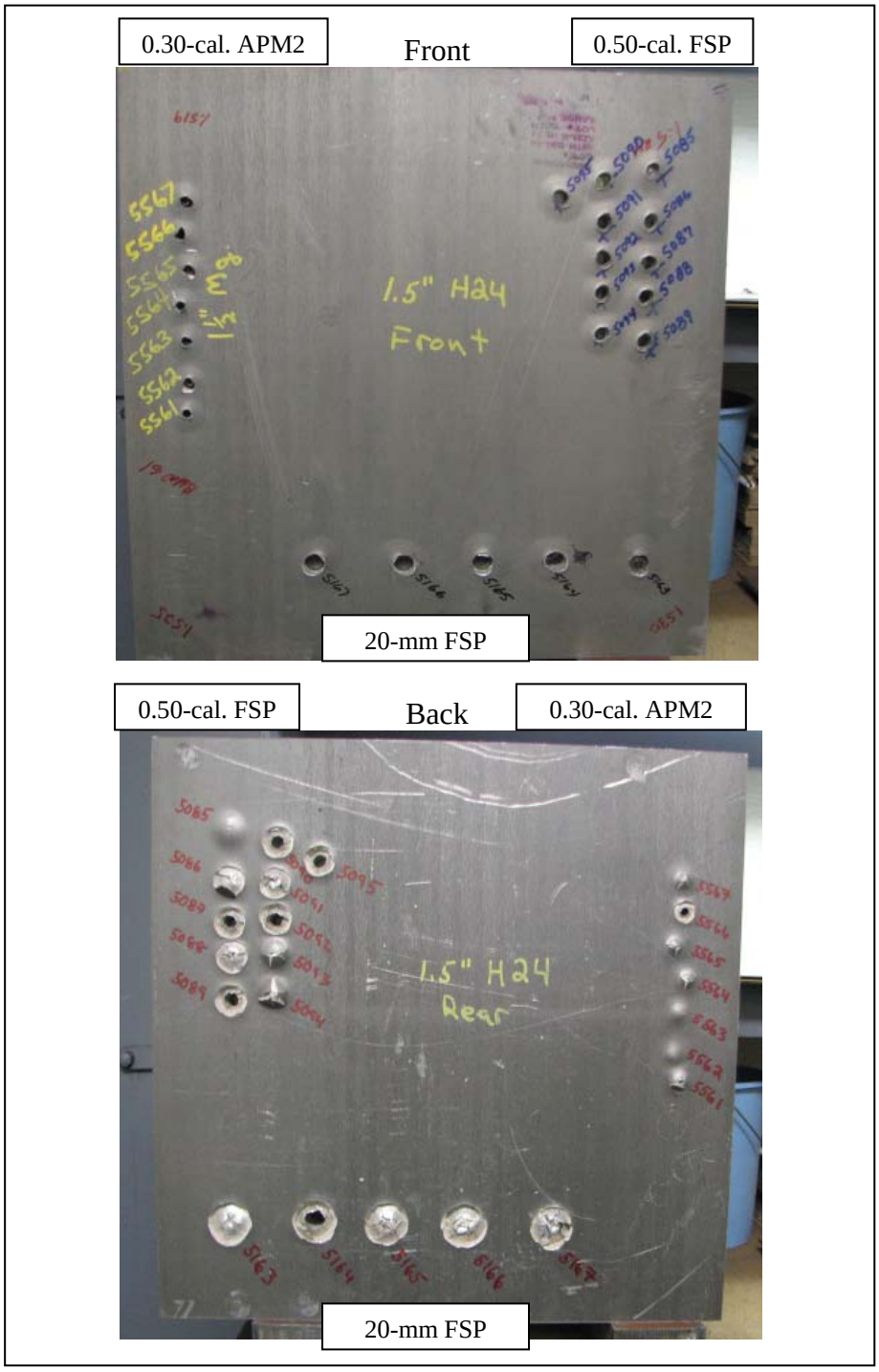


Figure A-2. The 1.5-in AZ31B-H24.

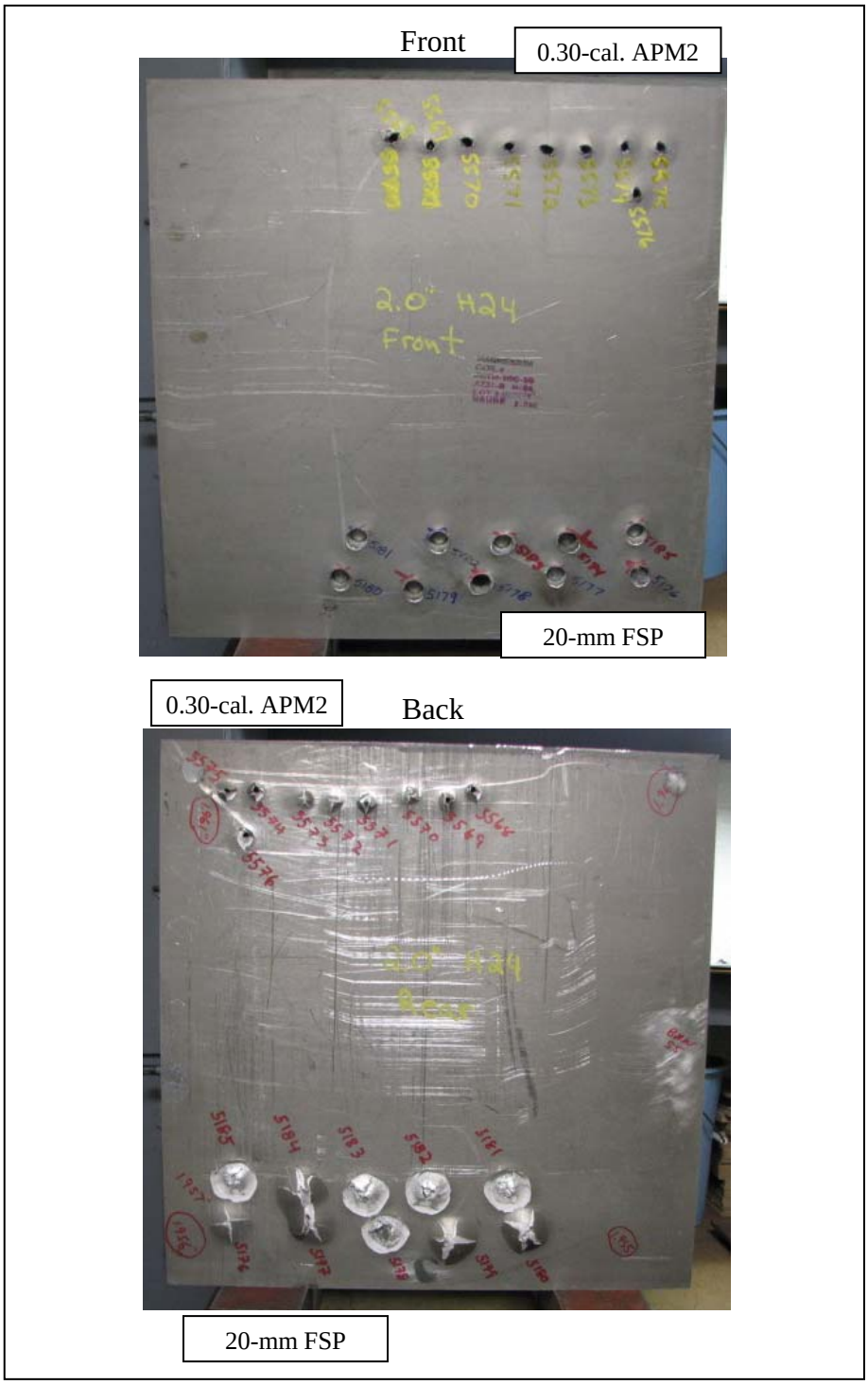


Figure A-3. The 2.0-in AZ31B-H24.

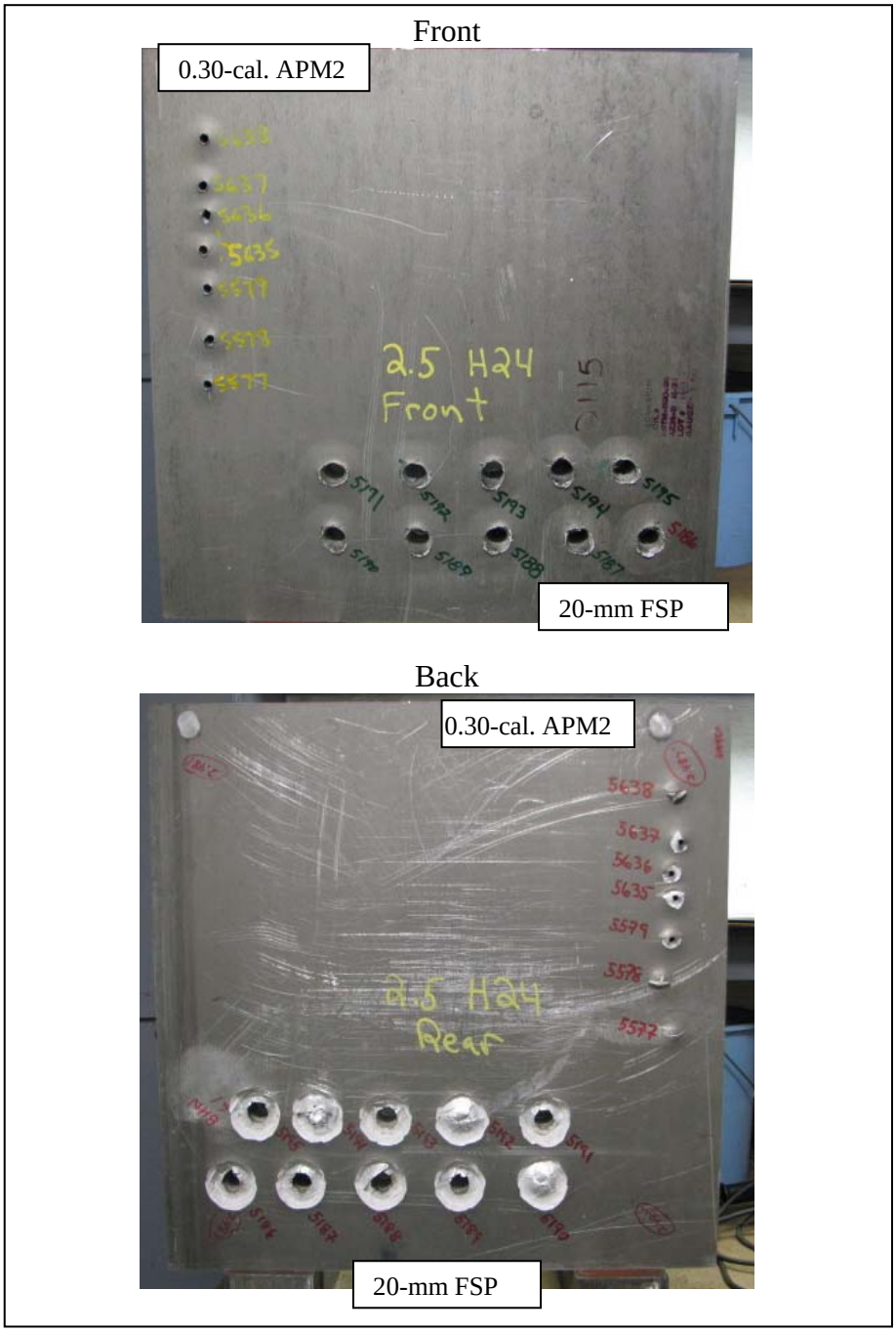
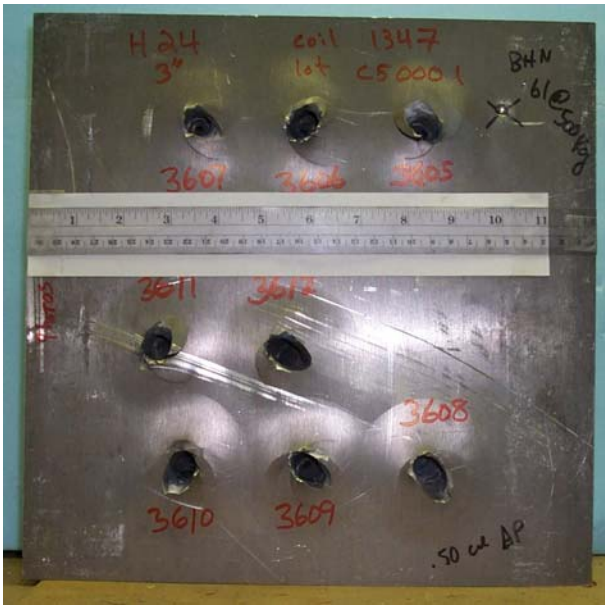


Figure A-4. The 2.5-in AZ31B-H24.

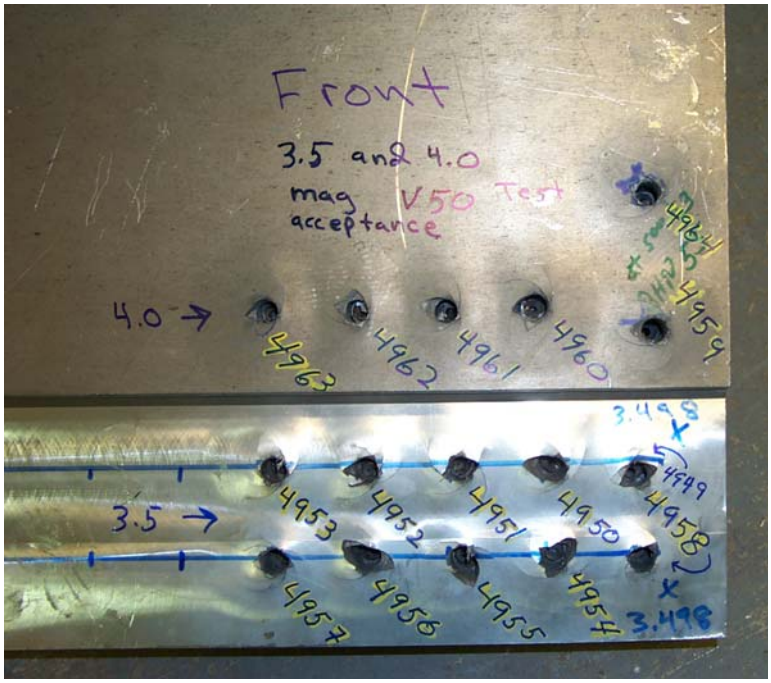
Front



Back

Figure A-5. The 3.0-in AZ31B-H24: 0.50-cal. APM2 impacts.

Front



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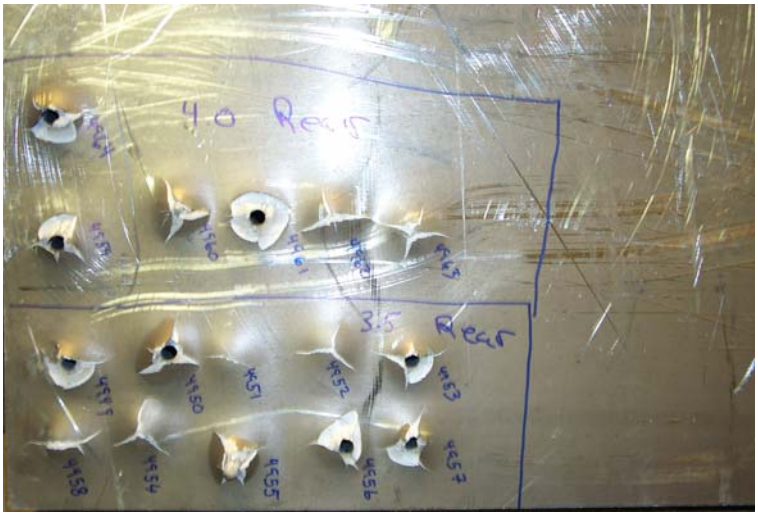

Figure A-6. The 3.5- and 4.0-in AZ31B-H24: 0.50-cal. APM2 impacts.

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Appendix B. Fragment-Simulating Projectile (FSP) Data for Post-Ballistic Pictures*

List of Definitions and Abbreviations

CP	Complete penetration; penetrator/target material exits rear surface of target.
PIP	Penetrator in plate; penetrator lodged in impact crater.
Pitch	Attitude of projectile in the vertical direction.
PP	Partial penetration; the penetrator is defeated by the target.
Plug	Target material ejected off rear of the plate.
Result	Result of shot; CP or PP.
Striking Velocity	Velocity of the projectile just before it impacts the target.
TP	Tip protruding out the back of the target.
Yaw	Attitude of projectile in the horizontal direction.

*The charts in this appendix appear in their original form, without editorial change.

Target: **Magnesium AZ31B-H24** **8-May-06**
Plate #: **--** **EF108**
Lot#: --
Thickness: **25.019mm 0.985 "**

Hardness: **57 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.50 cal FSP**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**507**	**m/s**	**# shots:**	**6**	
Std Dev:	**11**	**m/s**	**Spread:**	**24**	**m/s**
ZMR:	**0**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
639	--	--	CP	No	--	5070
519	**--**	**--**	**CP**	**Yes**	**--**	**5071**
417	--	--	PP	No	--	5072
479	--	--	PP	No	--	5073
511	**--**	**--**	**CP**	**Yes**	**--**	**5074**
456	--	--	PP	No	--	5075
448	--	--	PP	No	--	5076
495	**--**	**--**	**PP**	**Yes**	**--**	**5077**
441	--	--	PP	No	--	5078
498	**--**	**--**	**PP**	**Yes**	**--**	**5081**
470	--	--	PP	No	--	5082
498	**--**	**--**	**PP**	**Yes**	**--**	**5083**
518	**--**	**--**	**CP**	**Yes**	**--**	**5084**

Target: **Magnesium AZ31B-H24** **9-May-06**
Plate #: **--** **EF108**
Lot#: --
Thickness: **38.735mm 1.525 "**

Hardness: **61 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.50 cal FSP**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**742**	**m/s**	**# shots:**	**6**	
Std Dev:	**9**	**m/s**	**Spread:**	**27**	**m/s**
ZMR:	**0**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
630	--	--	PP	No	--	5085
729	--	--	PP	No	--	5086
764	--	--	CP	No	--	5087
738	**--**	**--**	**PP**	**Yes**	**--**	**5088**
762	--	--	CP	No	--	5089
746	**--**	**--**	**CP**	**Yes**	**--**	**5090**
738	**--**	**--**	**PP**	**Yes**	**--**	**5091**
757	**--**	**--**	**CP**	**Yes**	**--**	**5092**
720	--	--	PP	No	--	5093
730	**--**	**--**	**PP**	**Yes**	**--**	**5094**
745	**--**	**--**	**CP**	**Yes**	**--**	**5095**

Target: **Magnesium AZ31B-H24** **4-Jun-07**
Plate #: **ASTM B90-98** **EF108**
Lot#: --
Thickness: **38.74mm 1.525 "**

Hardness: **61 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **20mm FSP**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**477**	**m/s**	**# shots:**	**4**	
Std Dev:	**6**	**m/s**	**Spread:**	**13**	**m/s**
ZMR:	**0**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
773	--	--	PP	No	--	5163
485	**--**	**--**	**CP**	**Yes**	**--**	**5164**
472	**--**	**--**	**PP**	**Yes**	**--**	**5165**
476	**--**	**--**	**PP**	**Yes**	**--**	**5166**
476	**--**	**--**	**CP**	**Yes**	**--**	**5167**

Target: **Magnesium AZ31B-H24** **5-Jun-07**
Plate #: **ASTM B90-98** **EF108**
Lot#: --
Thickness: **49.73mm 1.958 "**

Hardness: **55 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **20mm FSP**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**576**	**m/s**	**# shots:**	**4**	
Std Dev:	**7**	**m/s**	**Spread:**	**15**	**m/s**
ZMR:	**4**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
540	--	--	PP	No	--	5176
549	--	--	PP	No	--	5177
585	**--**	**--**	**CP**	**Yes**	**--**	**5178**
569	--	--	PP	No	--	5179
567	--	--	PP	No	--	5180
574	**--**	**--**	**PP**	**Yes**	**--**	**5181**
573	**--**	**--**	**PP**	**Yes**	**--**	**5182**
572	--	--	PP	No	**--**	5183
569	--	--	PP	No	**--**	5184
570	**--**	**--**	**CP**	**Yes**	**--**	**5185**

Target: **Magnesium AZ31B-H24** **11-Jun-07**
Plate #: **ASTM B90-98** **EF108**
Lot#: --
Thickness: **63.119mm 2.485 "**

Hardness: **61 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **20mm FSP**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**735**	**m/s**		**# shots:**	**4**	
Std Dev:	**4**	**m/s**		**Spread:**	**9**	**m/s**
ZMR:	**3**					

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
834	--	--	CP	No	--	5186
816	--	--	CP	No	--	5187
806	--	--	CP	No	--	5188
768	--	--	CP	No	--	5189
714	--	--	PP	No	--	5190
731	**--**	**--**	**CP**	**Yes**	**--**	**5191**
723	--	--	PP	No	--	5192
734	**--**	**--**	**PP**	**Yes**	**--**	**5193**
733	**--**	**--**	**PP**	**Yes**	**--**	**5194**
740	**--**	**--**	**CP**	**Yes**	**--**	**5195**

Appendix C. APM2 Projectile Data for Post-Ballistic Pictures*

List of Definitions and Abbreviations

CP	Complete penetration; penetrator/target material exits rear surface of target.
PIP	Penetrator in plate; penetrator lodged in impact crater.
Pitch	Attitude of projectile in the vertical direction.
PP	Partial penetration; the penetrator is defeated by the target.
Plug	Target material ejected off rear of the plate.
Result	Result of shot; CP or PP.
Striking Velocity	Velocity of the projectile just before it impacts the target.
TP	Tip protruding out the back of the target.
Yaw	Attitude of projectile in the horizontal direction.

*The charts in this appendix appear in their original form, without editorial change.

Target:	**Magnesium AZ31B-H24**	**20-Apr-06**
Plate #:	**--**	**EF106**
Lot#:	--	
Thickness:	**38.74mm 1.525 "**	

Hardness:	**61 BHN on 500kg scale**
Obliquity:	**0°**
Projectile:	**.30 cal APM2**

Setup: Mg-Air(6")-AL 2024(0.020")

			#		
V50:	**579**	**m/s**	**shots:**	**4**	
Std Dev:	**6**	**m/s**	**Spread:**	**11**	**m/s**
ZMR:	**0**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
584	**--**	**--**	**CP**	**Yes**	**--**	**5561**
543	--	--	PP	No	medium bulge	**5562**
550	--	--	PP	No	medium bulge with crack	**5563**
564	--	--	PP	No	large bulge with cracks: PIP, TP	**5564**
574	**--**	**--**	**PP**	**Yes**	**large bulge with cracks: PIP, TP**	**5565**
584	**--**	**--**	**CP**	**Yes**	**--**	**5566**
573	**--**	**--**	**PP**	**Yes**	**PP, TP**	**5567**

Target: **Magnesium AZ31B-H24** **24-Apr-06**
Plate #: **--** **EF106**
Lot#: --
Thickness: **49.73mm 1.958 "**

Hardness: **61 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.30 cal APM2**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**687**	**m/s**	**# shots:**	**4**	
Std Dev:	**8**	**m/s**	**Spread:**	**18**	**m/s**
ZMR:	**9**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
729	--	--	CP	No	--	5568
698	--	--	CP	No	--	5569
658	--	--	PP	No	PIP, TP	5570
665	--	--	PP	No	PIP, TP	5571
662	--	--	PP	No	large bulge with cracks	5572
676	**--**	**--**	**PP**	**Yes**	**large bulge with cracks**	**5573**
684	**--**	**--**	**CP**	**Yes**	**--**	**5574**
693	**--**	**--**	**PP**	**Yes**	**Hole in target; dent in witness**	**5575**
694	**--**	**--**	**CP**	**Yes**	**--**	**5576**

Target: **Magnesium AZ31B-H24** **25-Apr-06**
Plate #: **--** **EF106**
Lot#: --
Thickness: **63.5mm 2.485 "**

Hardness: **61 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.30 cal APM2**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**787**	**m/s**	**#shots:**	**4**		
Std Dev:	**7**	**m/s**	**Spread:**	**15**	**m/s**	
ZMR:	**3**					

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
757	--	--	PP	No	medium bulge with cracks	5577
792	**--**	**--**	**PP**	**Yes**	**large bulge with cracks**	**5578**
805	--	--	CP	No	--	5579
804	--	--	CP	No	--	5635
789	**--**	**--**	**CP**	**Yes**	**--**	**5636**
791	**--**	**--**	**CP**	**Yes**	**--**	**5637**
777	**--**	**--**	**PP**	**Yes**	**PP, TP**	**5638**

Target: **Magnesium AZ31B-H24** **3-Apr-06**
Plate #: **--** **EF108**
Lot#: --
Thickness: **76.48mm 3.011 "**

Hardness: **61 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.50 cal AP M2**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**650**	**m/s**	**# shots:**	**4**	
Std Dev:	**5**	**m/s**	**Spread:**	**10**	**m/s**
ZMR:	**0**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
621	--	--	PP	No	Med. bulge w/crack	3605
696	--	--	CP	No	--	3606
661	--	--	CP	No	--	3607
655	**--**	**--**	**CP**	**Yes**	**--**	**3608**
647	**--**	**--**	**PP**	**Yes**	**Lg. bulge; star break**	**3609**
653	**--**	**--**	**CP**	**Yes**	**--**	**3610**
629	--	--	PP	No	**Lg. bulge w/cracks**	3611
645	**--**	**--**	**PP**	**Yes**	**Lg. bulge; star break**	**3612**

Target: **Magnesium AZ31B-H24** **2-Apr-07**
Plate #: **--** **EF108**
Lot#: --
Thickness: **88.93mm 3.501 "**

Hardness: **55 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.50 cal AP M2**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**688**	**m/s**	**# shots:**	**6**	
Std Dev:	**9**	**m/s**	**Spread:**	**25**	**m/s**
ZMR:	**0**				

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
714	--	--	CP	No	--	4949
706	--	--	CP	No	--	4950
650	--	--	PP	No	--	4951
661	--	--	PP	No	--	4952
697	**--**	**--**	**CP**	**Yes**	**--**	**4953**
672	**--**	**--**	**PP**	**Yes**	**--**	**4954**
687	**--**	**--**	**PP**	**Yes**	**--**	**4955**
694	**--**	**--**	**CP**	**Yes**	**--**	**4956**
692	**--**	**--**	**CP**	**Yes**	**--**	**4957**
684	**--**	**--**	**PP**	**Yes**	**--**	**4958**

Target: **Magnesium AZ31B-H24** **2-Apr-07**
Plate #: **--** **EF108**
Lot#: --
Thickness: **102.03mm 4.017 "**

Hardness: **55 BHN on 500kg scale**
Obliquity: **0°**
Projectile: **.50 cal AP M2**

Setup: Mg-Air(6")-AL 2024(0.020")

V50:	**746**	**m/s**	**# shots:**	**4**		
Std Dev:	**7**	**m/s**	**Spread:**	**15**	**m/s**	
ZMR:	**0**					

Striking Velocity (m/s)	Pitch (deg)	Yaw (deg)	Result (PP/CP)	Used for V50	Comments	Shot #
769	--	--	CP	No	--	4959
--	--	--	--	--	uncaptured data	4960
755	**--**	**--**	**CP**	**Yes**	**--**	**4961**
740	**--**	**--**	**PP**	**Yes**	**--**	**4962**
740	**--**	**--**	**PP**	**Yes**	**--**	**4963**
748	**--**	**--**	**CP**	**Yes**	**--**	**4964**

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